THE EFFECTS OF ALCOHOL INGESTION ON HUMAN PERFORMANCE

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THESIS

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The Effects of Alcohol Ingestion on Human Performance

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ABSTRACT

This experiment investigated the effects of alcohol ingestion on three measures of human performance: (a) information processing time, (b) reaction time and (c) movement time. The relationship between the alcohol effects and the drinking history of the subjects was also examined in order to determine the existence of any alcohol adaptation. In addition, the influence of alcohol on manifest anxiety was investigated. The analyses of variance and correlation analysis which were performed showed that dosage had a significant effect on information processing time and reaction time but had no significant effect on movement time. The rate of ingestion, except at the highest rate of 3 oz/35 min, did not significantly contribute to the effects of dosage. There was no significant correlation between alcohol effects and drinking history or manifest anxiety changes. The results of this study indicate that, even at small dosages, alcohol has a great effect on cognitive ability. It was also shown that alcohol effects psychomotor performance to a lesser degree and has little effect on neuromuscular performance.

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I. INTRODUCTION

Numerous laboratory studies have shown that human performance is adversely affected by alcohol ingestion. Virtually all of the studies dealing with alcohol ingestion consider dosage in terms of blood alcohol level in milligrams percent (mg %). To obtain blood alcohol in percentage terms, mg % is divided by 1000. The expected clinical state for various levels is indicated in Table 1.

Chart for Acute Intoxication - Alcohol
Ethyl Alcohol Blood Levels[1]

Absolute Percent	mg %	Physical state
0 - 0.05	0-50	Not intoxicated
0.05 - 0.15	50-150	May show physical signs (Legal intoxication in California is 100 mg %)
0.25 - 0.30	250-300	Definite intoxication
0.30 - 0.45	300-450	Dangerously intoxicated
0.45 - 0.55	450-550	Coma
0.60 - 0.70	600-900	Death

Table 1

Alcohol is primarily (90 percent) detoxified by oxidation with a mean difference rate of 10-20 mg %/hour.

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[1] Department of the Navy Publication NavMed P-5116, Drug Abuse (Clinical Recognition and Treatment, Including the Diseases Often Associated), January 1973.

In a study by Chiles and Jennings [1969] reaction time and tracking were shown to be markedly affected by blood alcohol levels of 109 mg %. Another study by Loomis and West [1958] showed tracking degradation with a blood alcohol level as low as 68 mg %. Billings, Wick, Gerke and Chase [1973] required experienced and non-experienced pilots to conduct simulated night instrument flights while under the influence of each of four blood alcohol levels (0, 40, 80, and 120 mg %). During each flight four instrument landing system (ILS) approaches were flown. Their results showed that blood alcohol levels as low as 40 mg % were associated with substantial increases in the number and seriousness of procedural errors that were committed. These findings may explain the results of a study by Harper and Albers [1964]. In a survey of general aviation fatal accidents, they found that in 35.4% of the cases the pilot had a blood alcohol level greater than 15 mg %. Similarly, in a study of fatal, single-vehicle accidents, Haddon and Brodess [1959] found that half of the drivers had blood alcohol levels in excess of 150 mg % at the time of death. Another 20% of the drivers showed levels between 50 and 150 mg %.

The majority of studies on alcohol consumption deal with the effects of high blood alcohol levels (greater than 100 mg %) on human performance. "There exists an attitude that adverse effects of moderate doses of alcohol can be mitigated through motivation, increased

attention to one's behavior or exercise of caution."[2] The studies cited above indicate that moderate doses of alcohol are not consistent with skilled performance. Studies utilizing self-estimates of alcohol effects by the subjects, as was done by Myrston, Kelly, Neri and Rydberg [1970], show that a false feeling of well-being exists at blood alcohol levels less than acute. At high blood alcohol levels, the subject is generally accurate in estimating lowered capacities. The combination of over-confident "joie de vivre" and degraded performance is potentially far more dangerous in general aviation or automobile operations than that of the drunk who recognizes his or her drunkenness.

The main purpose of this study was to quantify the effects of various levels of blood alcohol (19.1 mg %-203.7 mg %) on a specific indicator of cognitive ability - information processing time. Information processing time is the time required for a human receiver to correctly respond to a given amount of information. The amount of information is frequently expressed in terms of "bits" - the logarithm to the base two of the number of equally likely alternatives. (Human Engineering Guide, 1972) The following formula is used to calculate the number of bits of information:

$$\#\ \text{bits} = \text{Log}_2\ A$$

where A is the number of alternatives.

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[2] Pearson, R. G. "Alcohol-Hypoxia Effects upon Operator Tracking, Monitoring and Reaction Time," Aerospace Medicine, v. 39, p. 303-7 March 1968.

Through the experimental procedure, the effects of alcohol on simple reaction time and movement time were also examined.

A second purpose of the study was to determine what relationship, if any, existed between a person's drinking habits and the effects of alcohol ingestion. Greneell [1957] has suggested that physiological and psychological factors can produce "alcohol adaptation" or tolerance in a subject after a long history of consistent alcohol ingestion. However, as indicated in a research survey by Levine and Greenbaum [1973], there has been insufficient investigation to provide concrete evidence of the existence or absence of this tolerance. Therefore, the "type of drinker" should be included in any study of alcohol effects. Since it has been suggested that alcohol is anxiety-producing, (NavMed, P.-5116) the quantitative effects of alcohol on anxiety level were also measured.

II. METHOD

A. SUBJECTS

Nine military officers, all volunteers, were used in the experiment. Their ages ranged between 30 and 38 with a mean age of 32 years old. Their mean weight and height was 180 lbs, 72 in., with a range of 155 to 212 lbs. and 70 to 76 inches respectively. On the average, the subjects had been using moderate amounts of alcoholic beverages (five to seven oz./week) for the last 14 years. All subjects were considered to be in good physical condition at the start of testing. In addition, each subject had eaten two to four hours prior to the test and had not used alcoholic beverages for at least the previous 24 hours. Four of the subjects were left-handed, the other five right-handed. The subjects used their preferred hand during the test. The mean anxiety level for all subjects as measured by The Taylor Manifest Anxiety Test (1953) was determined to be 31 with a range between 16 and 54.

B. APPARATUS

The subjects performed the task in an Industrial Acoustic Company (IAC) Sound Reduction Chamber. The stimulus, a random number from one to eight, was displayed on a 1-3/8 inch by 5/8 inch light mosaic readout mounted on the response table. The readout

was approximately two feet from the subject's eyes and easily readable. The response table had a "rest" push button located at the front center. The eight response push buttons were located in an 11 inch semi-circle around the rest button with a 20^{o} separation. All nine push buttons were of red plastic and one inch in diameter. The eight response buttons were of the momentary contact normally open type. The rest push button was continuously energized when depressed. The back of the response table was elevated 11^{o} to enhance arm movement. (See Figure 1)

The experimenter initiated each random number by means of an advance button located outside the Sound Reduction Chamber. This push button operated on Ohr-tronics paper tape reader. The paper tape contained a series of random numbers one through eight. Each number was separated by a zero. A light located adjacent to the "advance" button indicated when the subject had the rest button energized.

A Lab 8/e analog/digital computer provided the clock for all timing sequences. See Figures 2 and 3 for the layout of the monitor/advance station and relative positions of the computer, chamber and monitoring station.

C. EXPERIMENTAL TASKS AND PROCEDURES

Each subject was tested periodically throughout two three-hour test periods, one with alcohol ingestion and one without. The order in

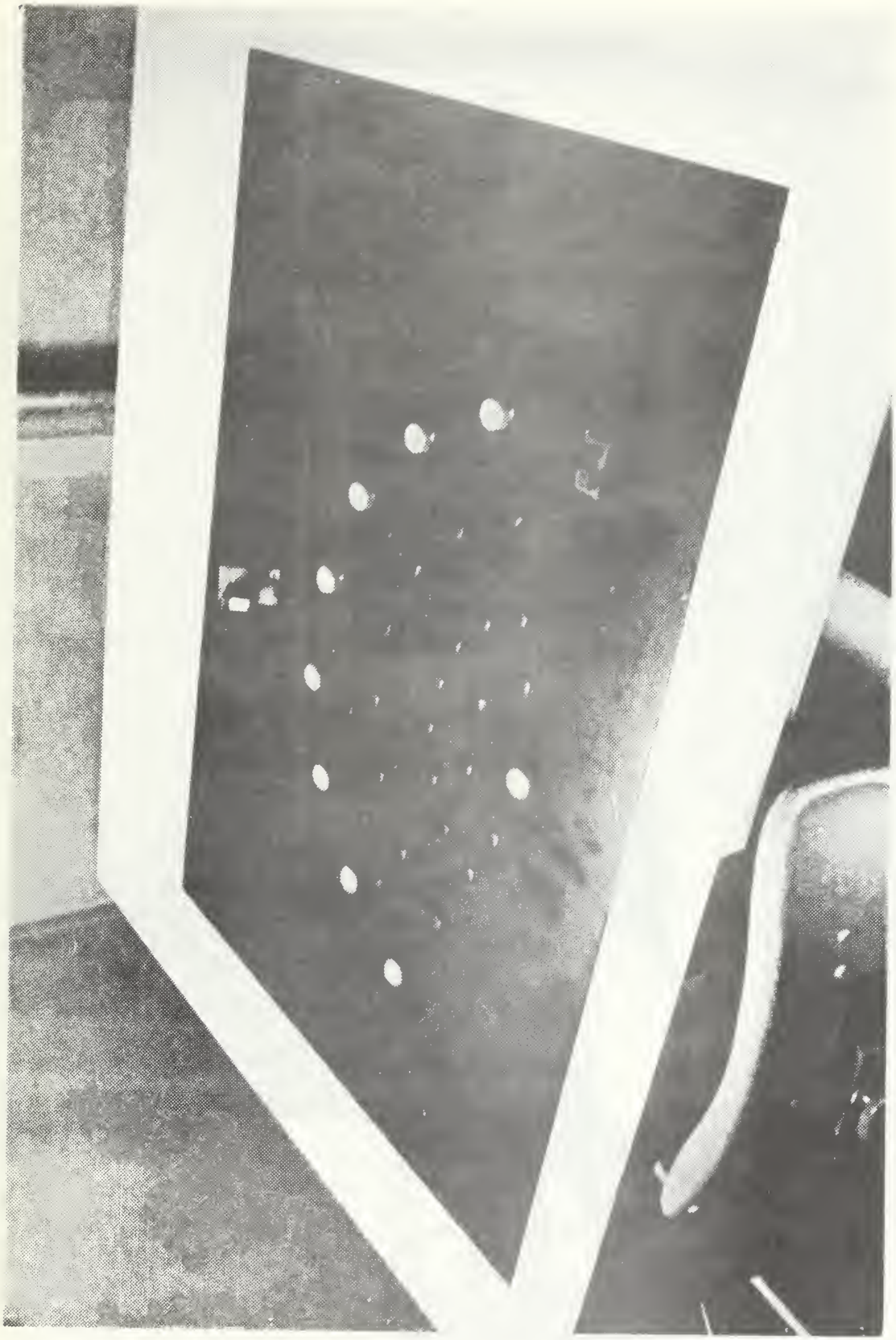

FIGURE 1

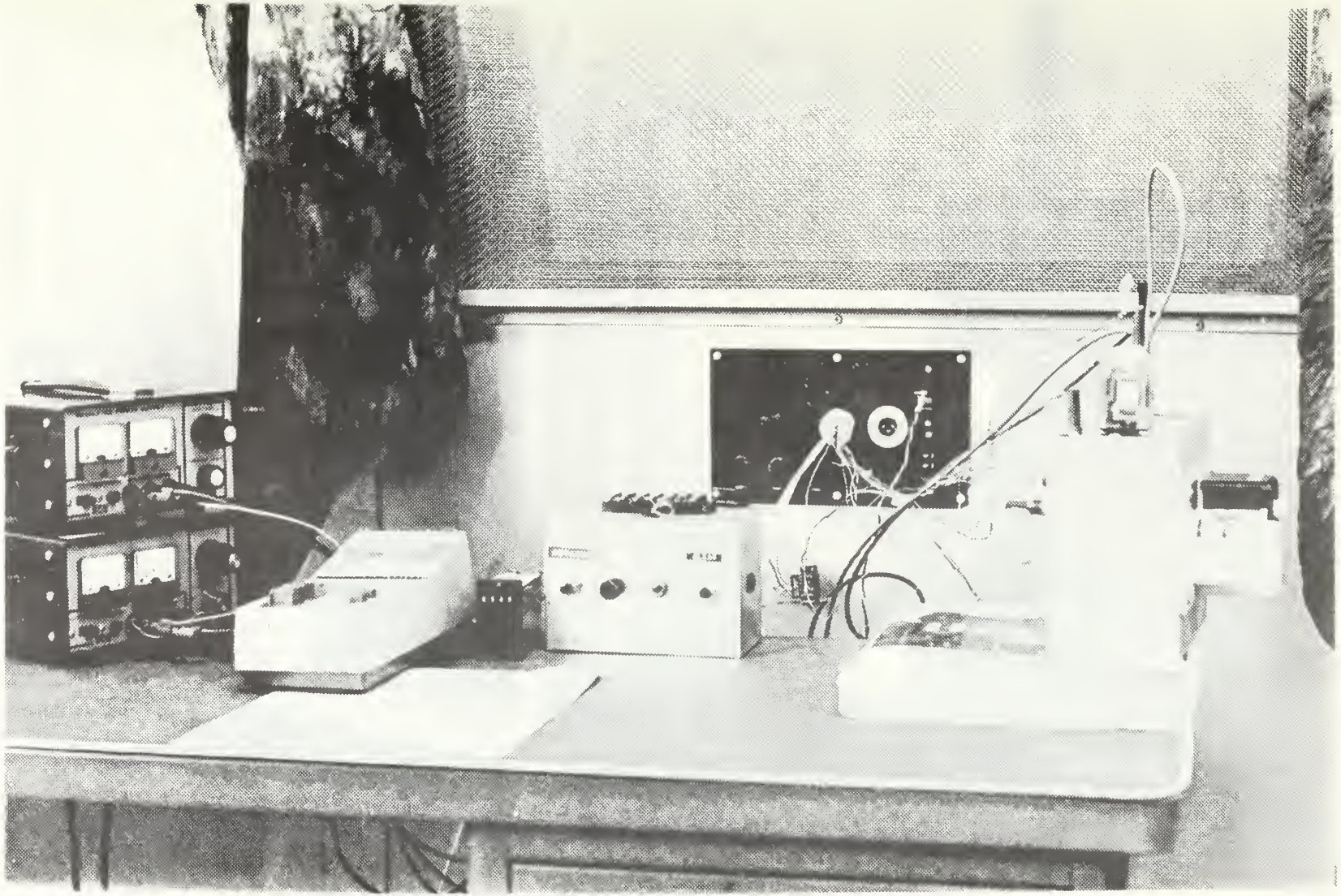

FIGURE 2

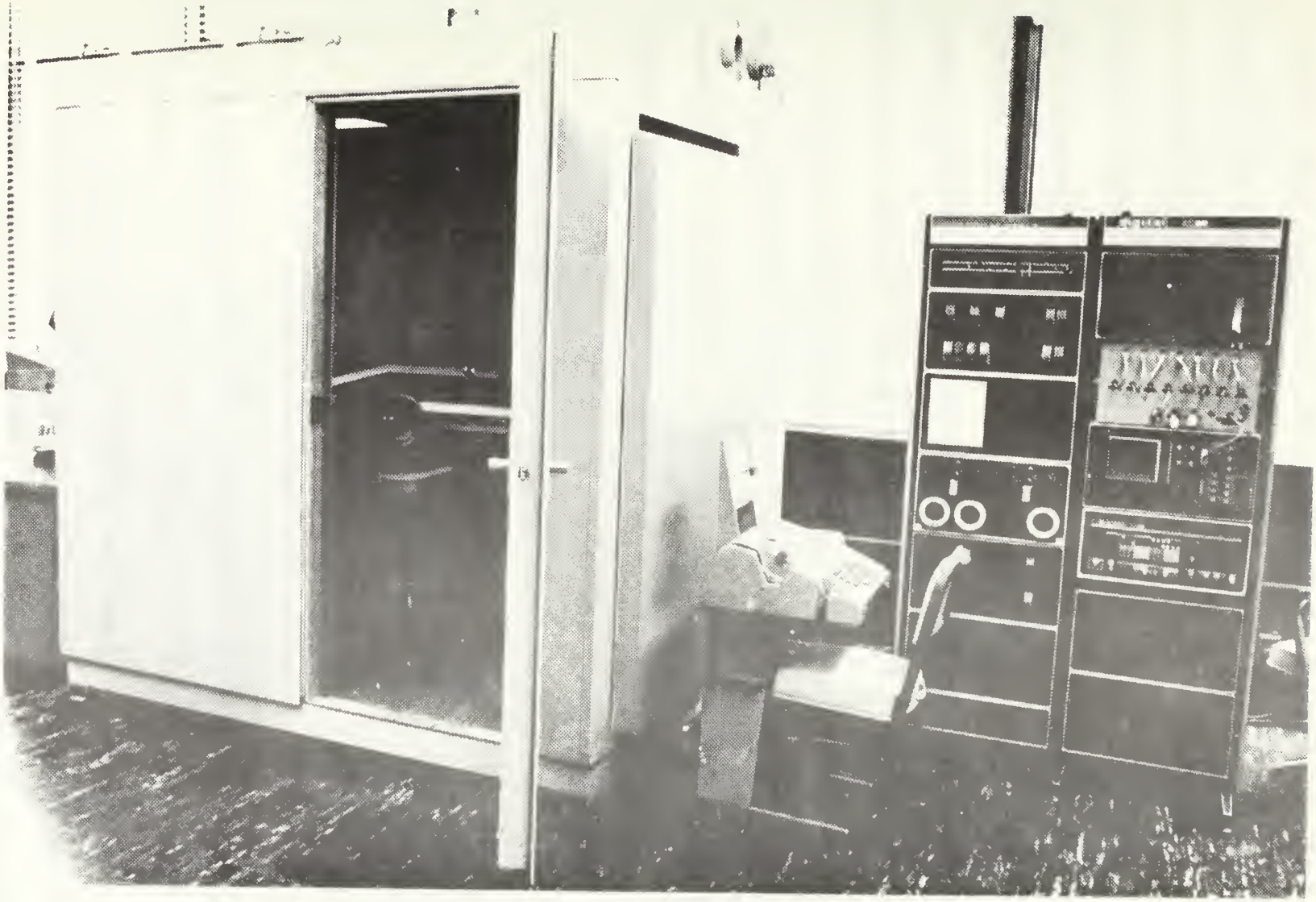

FIGURE 3

which the test periods were given was determined randomly. Five subjects were given the alcohol ingestion portion first, the remaining four had the baseline (no alcohol) test period first. The testing involved responding to a three-bit (eight alternatives) information processing task. The controlled variable was the amount of alcohol ingested. The dependent variable was the time required to make the correct response. The anxiety test was given at the start and completion of each period. A copy of this test is found in Appendix A.

Height and weight measurements were made on each subject after completion of the first anxiety test of the first test period. In addition, the subjects were required to answer two questions in order to determine their drinking history. These two questions were:

1. How long have you been using alcohol beverages?
2. Do you drink whiskey:

Never?		_____
Seldom? (1.5-4.5 oz/week)	1-3 shots	_____
Moderate? (6.0-10.5 oz/week)	4-7 shots	_____
Heavy (more than 10.5 oz/week)	7 shots	_____

A waiver of responsibility (see Appendix B) was completed by each subject at the start of the test period involving alcohol ingestion. An instruction sheet was presented to each subject prior to the start of the practice test. A copy of the instruction is contained in Appendix C. The practice test was given immediately before the first actual test in

each test period. The practice test and the actual tests were identical. Each consisted of 50 trials. Each trial was initiated by the experimenter. When the random number was displayed, the subject was required to immediately leave the start button, push the correct response button and return to the start button. The random number would not be extinguished (read zero) until the correct response was made. The 50 trials were initiated with a random delay of two to five seconds after the subject returned to the start button. The sequence of 50 trials (1 test) took 3.5 minutes to complete. Five tests, spaced 35 minutes apart comprised the test period.

During the alcohol ingestion tests the alcohol was administered within 1.5 minutes after each 50 trial test. The alcohol used was 90 proof Bourbon.

The nine subjects were divided into three groups of three on the basis of the amount of alcohol to be ingested. One group was given a total of twelve ounces per subject in four three ounce doses. The second group was given a total of nine ounces per subject in four 2.25 ounce doses. The last group was given a total of six ounces per subject in four 1.5 ounce doses. All dosages were mixed with four and a half ounces of water. The subjects were allowed ten minutes in which to ingest each dose. Twenty minutes after the time alloted for complete ingestion, (thirty minutes after receiving each dose) the first trial of the next test was initiated. The test period ended when the

second anxiety test was completed. A test period schedule is shown in Table 2.

TEST PERIOD SCHEDULE

Time (hr + min.)	Event
0 + 00	Anxiety test
0 + 15	Ht. and Wt. Measurements and Inf. Proc. task practice.
0 + 25	Information Processing task 1.
0 + 30	Intake of 1/4 total alcohol *
0 + 50	Intake completed. *
1 + 00	Information Processing task 2.
1 + 05	Intake of 1/4 total alcohol. *
1 + 15	Intake completed. *
1 + 35	Information Processing task 3.
1 + 40	Intake of 1/4 total alcohol. *
1 + 50	Intake completed. *
2 + 10	Information Processing task 4.
2 + 15	Intake of 1/4 total alcohol. *
2 + 25	Intake completed. *
2 + 45	Information Processing task 5.
2 + 50	Anxiety test.
3 + 00	Test complete.

*Applies only to alcohol ingestion test periods.

Table 2

III. PRESENTATION OF DATA

A. DATA COLLECTION

The test apparatus provided analog information, in the form of voltage changes, to the computer. The computer was programmed (see Appendix D) to start timing each trial upon initiation by the experimenter. When the subject reacted to the stimulus presentation and removed his finger from the rest button, a voltage drop was registered in the computer and the time was recorded. This time interval represented gross reaction time. Because of the electro-mechanical properties of the push-buttons and tape-reader, there existed a constant operating delay of approximately 0.35 seconds. True reaction time was computed by reducing the gross reaction time by this 0.35 second delay. Response time, consisting of outward movement time plus information processing time was measured in the computer by recording the time interval between rest button release and depression of the correct response button. When the correct response was made, the computer registered a voltage increase and recorded the time. The interval between the time of correct response and rest button reactuation was considered pure inward-movement time. (It included physical movement and kinesthetic information processing.) When returning to the rest button, the subject had no alternative direction and, therefore,

zero bits of visual information. Prior to the start of testing, it was recognized that for physiological reasons relating to the different muscles used in each movement, pure outward-movement time (physical movement towards a single response button plus kinesthetic information processing) would be different than pure inward-movement time. An attempt was made to quantify this difference by measuring the pure outward and inward movement times for five individuals (non-subjects) on a total of 250 trials. The results indicated that pure outward-movement time averaged 0.3 seconds faster than pure inward-movement time. Visual information processing time was computed by subtracting inward-movement time from response time and adding the 0.3 second correction factor.

The computer program summed the values of reaction time, movement time and visual information processing time for all 50 trials of each run. These 50 trial sums are used for all the data analysis.

B. MEASURES

The base line data was collected on each subject in an attempt to remove the effects of learning, boredom and fatigue. By testing each subject twice, once without alcohol, each subject was made to act as his own control. The baseline results were subtracted from the results of the alcohol ingestion tests (see Appendix E). The alcohol ingestion test times were adjusted by the difference in the two initial tests.

(At 0 mg %) The differences between the remaining tests were the change in time attributed to the effects of the alcohol. This time difference was converted to a percentage change to eliminate the variance between the different subjects at 0 mg %. A sample computation is shown in Table 3.

Sample computation for percent change

	0	3 oz	6 oz	9 oz	12 oz
Alcohol ingestion	26.0	30.0	34.0	35.0	40.0
Base line	23.0	23.0	22.0	21.0	22.0
Initial test difference	3.0				
Adjusted alcohol ingestion	23.0	27.0	31.0	32.0	37.0
Base line	23.0	23.0	22.0	21.0	22.0
Time difference	0	4.0	9.0	11.0	15.0
Percentage change (Difference/Baseline)	0	17.39	40.91	52.38	68.18

Table 3

Graphs of percentage changes in visual information processing time, reaction time, and movement time for each of the three dosage levels are shown in Appendix F.

A similar procedure was used in calculating anxiety level changes. The percentage change in anxiety level was calculated for the effects of the total alcohol dosage consumed by the subject.

In order to measure the effects of drinking history on visual information processing time, reaction time, and movement time, it was necessary to weight the drinking type numerically. The weighting criteria used is shown in Table 4.

Type Drinker Weighting Criteria

Never? (less than 1.5 oz/week)	1
Seldom? (1.5-4.5 oz/week)	3
Moderate? (6.0-10.5 oz/week)	8
Heavy? (more than 10.5 oz/week)	12

Table 4

Blood alcohol level was computed by the equation shown in Table 5 [Billings, et al 1973]

Blood Alcohol Level Equation

$$BAmax = \frac{60cq}{w}$$

where BAmax = maximum blood alcohol concentration, in mg %

c = percentage concentration of alcohol in beverage (90 proof is 45%)

q = quantity of beverage consumed, in ounces

w = body weight, in pounds

Table 5

A two-way analysis of variance (ANOVA) was performed on percent change in visual information processing time, reaction time, and movement time for each of the three subject groups (12 oz, 9 oz, and 6 oz).

A one-way analysis of variance was performed on percent change in visual information processing time, reaction time, movement time and anxiety level change. The treatments considered were the three total amounts consumed.

Linear regression analysis was performed on six independent variables (total dosage, mg %, age, height, total years drinking and type drinker) and three dependent variables (percent increase in information processing time, reaction time and movement time). Percent anxiety level change was not considered because it was not shown to be significant by the one-way analysis of variance.

The significance level (α) chosen for all analyses was 0.05.

IV. RESULTS AND DISCUSSION

Table 6 shows the results of the ANOVAS for visual information processing time. A significant difference was found between treatments at the twelve ounce dosage and for total dosages. However, a significant difference was not shown for subjects or treatments at either the nine ounce or six ounce dosage. For each total dosage, the incremental amount was ingested at the same rate, ten minutes for consumption and 35 minutes between increments. By considering the treatments as ingestion rates, the consumption of alcohol at a rate of 3 oz/35 min affected visual information processing time significantly. At ingestion rates of less than 3 oz/35 min, visual information processing time was not significantly affected by incremental dosage. For all three total dosages, however, visual information processing time did increase significantly (as shown in Table 6d). This indicates that for ingestion rates less than 3 oz/35 min, visual information processing time is affected, but no rate effect exists.

Table 7 shows the results of the ANOVAS for reaction time. It was observed that a significant difference existed between subjects and treatments at the twelve ounce dosage. A significant difference was also found between subjects at the six ounce dosage and between total dosages. A significant difference was not shown for subjects or treatments at the nine ounce dosage.

ANOVAS For Visual Information Processing Time

(3, 6, 9, 12 oz levels)

Source	SS	df	MS	F
subjects	3665.203	2	1832.602	1.39824
treatments (levels)	29988.69	3	9996.231	7.626935*
error	7863.891	6	1310.648	
total	41517.79	11		

(2¼, 4½, 6¾, 9 oz levels)

subjects	1907.886	2	953.9429	4.273192
treatments (levels)	2537.42	3	845.8068	3.788796
error	1339.434	6	223.2389	
total	5784.74	11		

(1½, 3, 4½, 6 oz levels)

subjects	1727.022	2	863.511	1.767448
treatments (levels)	424.4824	3	141.4941	.2896124
error	2931.383	6	488.5638	
total	5082.887	11		

(Total dosage)

treatments (dosage)	9697.178	2	4848.589	13.29912**
error	2187.479	6	364.5798	
total	11884.66	8		

*α = .025
**α = .01

Table 6

ANOVAS For Reaction Time

(3, 6, 9, 12 oz levels)

Source	SS	df	MS	F
subjects	2385.731	2	1192.866	6.315195*
treatments (levels)	9581.448	3	3193.816	16.9085***
error	1133.329	6	188.8882	
total	13100.51	11		

($2\frac{1}{4}$, $4\frac{1}{2}$, $6\frac{3}{4}$, 9 oz levels)

subjects	1172.522	2	586.2609	4.209034
treatments (levels)	1029.697	3	343.2322	2.46422
error	835.718	6	139.2863	
total	3037.936	11		

($1\frac{1}{2}$, 3, $4\frac{1}{2}$, 6 oz levels)

subjects	958.7655	2	479.3828	10.11276**
treatments (levels)	131.272	3	43.75734	.9230779
error	284.4225	6	47.40374	
total	1374.46	11		

(Total dosage)

treatments (dosages)	8701.04	2	4350.52	15.88768***
error	1642.979	6	273.8299	
total	10344.02	8		

* α = .05
** α = .025
*** α = .005

Table 7

The significant difference between treatments at the twelve ounce dosage indicated that a 3 oz/35 min ingestion rate had a significant effect on reaction time. At lower dosages the amount ingested rather than the rate of ingestion affected reaction time.

A Duncan Multiple Range Test was performed on the twelve ounce and six ounce dosage in an attempt to determine what differences existed between subjects. At the twelve ounce dosage there existed a difference between subject 1 and subject 2 and subject 2 and subject 3. There was no difference between subject 1 and subject 3. At the six ounce dosage, there existed a difference between subjects 7 and 9 and subjects 7 and 8. There was no difference between subject 8 and subject 9.

Table 8 shows the results of the ANOVAS for movement time. There existed a significant difference between subjects at the six ounce dosage. A significant difference was not shown for subjects or treatments at either the nine ounce or twelve ounce dosage and no significant difference was shown between total dosages.

The lack of a significant difference in treatments indicates that neither ingestion rate, nor total dosage had a significant effect on movement time.

A Duncan Multiple Range Test was performed on the six ounce dosage in an attempt to determine what differences existed between subjects. It was shown that there existed a difference between subject 8 and subject 9 and subject 7 and subject 9. There was no difference between subjects 7 and 8.

ANOVAS For Movement Time

(3, 6, 9, 12 oz levels)

Source	SS	df	MS	F
subjects	580.5267	2	290.2633	2.644902
treatments (levels)	426.6733	3	142.2244	1.29596
error	658.4667	6	109.7444	
total	1665.667	11		

(2¼, 4½, 6¾, 9 oz levels)

subjects	41.625	2	20.8125	.8230894
treatments (levels)	8.67	3	2.89	.1142932
error	151.715	6	25.28583	
total	202.01	11		

(1½, 3, 4½, 6 oz levels)

subjects	63.645	2	31.8225	6.379741*
treatments (levels)	14.9692	3	4.9897	1.000334
error	29.9283	6	4.988055	
total	108.5425	11		

(Total Dosage)

treatments (dosage)	73.60889	2	36.80445	.3115032
error	708.9067	6	118.1511	
total	782.5155	8		

* α = .05

Table 8

Table 9 shows the results of the total dosage ANOVA for anxiety level change. A significant difference was not shown.

ANOVA For Anxiety Level Change

(Total Dosage)

Source	SS	df	MS	F
treatments (dosage)	547.6545	2	273.8273	.4817564
error	3410.362	6	568.3936	
total	3958.016	8		

Table 9

This seems to indicate that anxiety level, as measured in this study, is not significantly affected by different dosages of alcohol. Because two of the three twelve ounce dosage, subjects had difficulty in completing their second anxiety tests, any results obtained would be suspect.

Table 10 shows the correlation matrix for the six independent and three dependent variables. The critical value for a significant correlation coefficient is .666.[3]

A significant correlation existed between visual information processing time, total dosage ingested and final blood alcohol level. The other independent variables were not significantly correlated. A

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[3] Sokal, R. R. and Rohlf, F. J., Biometry-Statistical Tables, p. 225, W. H. Freeman and Co., 1969.

Correlation Matrix for Significant Variables

Description	Variable
total dosage ingested	x1
final blood alcohol level	x2
age	x3
height	x4
total years drinking	x5
type drinker	x6
percent change in visual information processing time	x7
percent change in reaction time	x8
percent change in movement time	x9

	x1	x2	x3	x4	x5	x6	x7	x8	x9
x1	1.00	0.95	0.12	0.00	0.26	-0.10	0.83	0.91	0.19
x2		1.00	0.03	-0.14	0.20	0.06	0.71	0.91	0.24
x3			1.00	0.08	0.71	-0.16	0.05	-0.20	0.05
x4				1.00	0.11	-0.14	-0.09	-0.09	0.65
x5					1.00	0.31	0.14	0.01	0.22
x6						1.00	-0.35	0.02	-0.01
x7							1.00	---	---
x8								1.00	---
x9									1.00

Table 10

similar relationship was shown for reaction time. It also had a significant correlation with total dosage ingested and final blood alcohol level. The correlation between blood alcohol and reaction time can help explain the results of the Duncan Range Test. For both the twelve ounce and the six ounce dosage, the subjects that were shown to be different (subject 2 and subject 7) had significantly different final blood alcohol levels in comparison to the other subjects at that dosage.

Movement time did not show any significant correlation with any independent variable. This agreed with the results of the movement time ANOVAs.

V. CONCLUSIONS AND SUMMARY

Visual information processing time was affected more by alcohol ingestion than either reaction time or movement time. At low blood alcohol levels (mean of 23 mg %) a significant increase in information processing time (mean of 59.67 %) was observed. The rate of ingestion had no significant effect on the increment time increase until ingestion rate reached a high (3 oz/35 min) level. At the highest blood alcohol levels (mean of 180 mg %) the percentage change in time (mean of 150.07 %) is significantly large.

Visual information processing time can be considered a measure of cognitive performance. Based upon the results of this study it appears that alcohol ingestion at all levels tested has a significant effect on cognition. Cognitive performance (i.e., visual information processing) decreased with a relatively small intake of alcohol. This decrease continued as more alcohol was ingested. A high ingestion rate (3 oz/35 min) compounded the decrease in cognitive performance significantly.

Reaction time can be considered a measure of psychomotor performance. Reaction requires the combined use of the central nervous system and the neuromuscular system. The results of this study indicate that a high alcohol ingestion rate (3 oz/35 min) has a significant effect on psychomotor performance. A high blood alcohol level has less

of an effect on psychomotor performance than on cognitive performance, however a significant effect was demonstrated on both. At a mean blood alcohol level of 180 mg % the mean increase in reaction time determined in this study was 83.53%. This is slightly more than half the increase shown in visual information processing time. At low blood alcohol levels, the decrease in psychomotor performance does not appear to be significant. The mean increase in reaction time observed in this study at a mean blood alcohol level of 23 mg % was 11.4%. The study did show that individual blood alcohol levels made a significant difference in psychomotor performance.

The increase in reaction time with increased blood alcohol levels is consistent with previous research findings. Chiles and Jennings [1969] found significant increases in reaction time at blood alcohol levels of 102 mg %. Another study by Carpenter [1959] showed similar increases at blood alcohol levels between 70 and 80 mg %.

Movement time differs from reaction time and can be considered a measure of neuromuscular performance. The difference is that the central nervous system can be considered much less involved in movement than in reaction. Simple movements such as those done in this study require little, if any, cognitive functioning. This study showed that no significant correlation between blood alcohol levels and movement time. At the highest mean blood alcohol dosage of 180 mg %, the mean increase was only 7.23%. These results indicate that neuromuscular performance is not adversely affected by blood alcohol.

Chiles and Jennings [1969] finding similar results stated, "The fact that movement time was not affected suggests that the alcohol caused a deterioration in some sort of central attentional or decision process rather than a direct alteration of the subject's neuromuscular system."

The subjects in this study were a hetrogeneous mixture of drinking types and also were varied in their manifest anxiety level. The results of the study did not show any significant relationship between their performance in any of the three measures and their drinking type or anxiety change. This indicates that alcohol adaption might not be based upon past drinking habits and alcohol intake does not significantly affect manifest anxiety.

Alcohol ingestion, even at low blood alcohol levels, has a significant effect on two human functions in any vehicular operation. Cognitive performance, the most affected function, becomes more important in more complicated operations. Flying an aircraft is considerably more complicated than driving and, as shown in a study by Mohler [1966], offers eight times or more the opportunity for error than in the case with driving.

The effect of decreased psychomotor performance, the other function shown to be affected by alcohol ingestion, becomes potentially more dangerous at the high speeds involved in aircraft operation. It becomes clear that the effects of alcohol ingestion will be more deleterious in the case of flying. Regardless of mental attitude, imagined

alcohol adaption or limited ingestion, the consumption of alcohol can lead to disasterous results in an automobile and even more certainly in an aircraft.

APPENDIX A

BIOGRAPHICAL INVENTORY

Mark each item with a number indicating how accurately it describes you.

+2 Describes me very accurately

+1 usually me

0 Sometimes me, sometimes not

-1 Not usually me

-2 Definitely not me

_____ 1. I do not tire quickly

_____ 2. I am often sick to my stomach

_____ 3. I am about as nervous as other people

_____ 4. I have very few headaches

_____ 5. I work under a great deal of strain

_____ 6. I cannot keep my mind on one thing

_____ 7. Once in a while I think of things too bad to talk about

_____ 8. I worry over money and business

_____ 9. My father was a good man

_____ 10. I frequently note my hand shakes when I try to do something

_____ 11. My sex life is satisfactory

_____ 12. I blish as often as others

_____ 13. I have diarrhea once a month or more

_____ 14. I worry quite a bit over possible troubles

_____ 15. Evil spirits possess me at times

_____ 16. I practically never blush

_____ 17. At times I feel like swearing

_____ 18. I have nightmares every few nights

_____ 19. I am often afraid I am going to blush

_____ 20. I have a cough most of the time

_____ 21. If people had not had it in for me I would have been more successful

_____ 22. My hands and feet are usually warm enough

_____ 23. I sweat very easily even on cool days

_____ 24. When embarrassed I often break out in a sweat that is very annoying

_____ 25. At times I feel like smashing things

_____ 26. Most any time I would rather sit and daydream than do anything else

_____ 27. I do not often notice my heart pounding and I am seldom short of breath

_____ 28. My family does not like the work I have chosen

_____ 29. I feel hungry almost all the time

_____ 30. Often my bowels don't move for several days at a time

_____ 31. I do not always tell the truth

_____ 32. When I am with people I am bothered by hearing very queer things

_____ 33. It would be better if almost all laws were thrown away

_____ 34. I have a great deal of stomach trouble

_____ 35. At times I lost sleep over worry

_____ 36. A minister can cure disease by praying and putting his hand on your head

_____ 37. I am liked by most people who know me

_____ 38. My sleep is restless and disturbed

_____ 39. As a youngster I was suspended from school one or more times for cutting up

_____ 40. I often dream about things I don't like to tell other people

_____ 41. I do not ready every editorial in the newspaper every day

_____ 42. I loved my father

_____ 43. I am easily embarrassed

_____ 44. I am more sensitive than most other people

_____ 45. I see things or animals or other people around me that others do not see

_____ 46. I think a great many people exaggerate their misfortunes in order to gain an advantage rather than to lose it

_____ 47. I get angry sometimes

_____ 48. I frequently find myself worrying about something

_____ 49. I wish I was happy as others

_____ 50. I am usually calm and not easily upset

_____ 51. Any man who is able and willing to work hard has a good chance of succeeding

_____ 52. Sometimes I am strongly attracted by the personal articles of others such as shoes, gloves, etc., so that I want to handle or steal them though I have no use for them

_____ 53. I cry easily

_____ 54. I feel anxious about something or someone almost all of the time

_____ 55. It takes a lot of argument to convince most people of the truth

_____ 56. Once in a while I put off until tomorrow what I ought to do today

_____ 57. I am happy most of the time

_____ 58. I have very few quarrels with members of my family

_____ 59. It makes me nervous to have to wait

_____ 60. At times I have been so restless that I cannot sit in a chair for very long

_____ 61. Sometimes when I am not feeling well I am cross

_____ 62. Sometimes I become so excited that I find it hard to get to sleep

_____ 63. I have often felt that I faced so many difficulties I could not overcome them

_____ 64. I frequently find it necessary to stand up for what I think is right

_____ 65. At times I have been worried beyond reason about something that really didn't matter

_____ 66. I do not have as many fears as my friends

_____ 67. I believe in law enforcement

_____ 68. I believe in a life hereafter

_____ 69. My table manners are not quite as good at home as when I am out in company

_____ 70. I believe I am being plotted against

_____ 71. I believe I am being followed

_____ 72. I have been afraid of things or people that I know could not hurt me

_____ 73. Most people will use somewhat unfair means to gain profit or an advantage rather than to lose it

_____ 74. Often I can't understand why I have been so cross and grouchy

_____ 75. At times my thoughts have raced ahead faster than I could speak them

_____ 76. If I could get into a movie without paying and be sure I was not seen I would probably do it

_____ 77. I certainly feel useless at times

_____ 78. I find it hard to keep my mind on a task or job

_____ 79. Criticism or scolding hurts me terribly

_____ 80. Sometimes I feel as if I must injure either myself or someone else

_____ 81. I am more self-conscious than most people

_____ 82. I have the wanderlust and am never happy unless I am roaming or traveling about

_____ 83. It makes me impatient to have people ask me advice or otherwise interrupt me when I am working on something important

_____ 84. I would rather win than lose in a game

_____ 85. Someone has been trying to poison me

_____ 86. I am the kind of person who takes things hard

_____ 87. I am a very nervous person

_____ 88. I have had periods in which I carried on activities without knowing later what I had been doing

_____ 89. Life is often a strain for me

_____ 90. I like to know some important people because it makes me feel important

_____ 91. I like to study and read about things that I am working at

_____ 92. At times I think I am no good at all

_____ 93. I have never felt better in my life than I do now

_____ 94. There is something wrong with my mind

_____ 95. I am not afraid to handle money

_____ 96. I am not at all confident of myself

_____ 97. What others think of me does not bother me

_____ 98. It makes me uncomfortable to put on a stunt at a party even when others are doing the same sort of thing

_____ 99. My mother was a good woman

_____ 100. I find it hard to make talk when I meet new people

_____ 101. I am against giving money to beggars

_____ 102. At times I feel that I am going to crack up

_____ 103. I commonly hear voices without knowing where they come from

_____ 104. My hearing is apparently as good as that of most people

_____ 105. I don't like to face a difficulty or make an important decision

_____ 106. I am very confident of myself

_____ 107. I do not like everyone I know

_____ 108. I like to visit places where I have never been before

_____ 109. Someone has been trying to rob me

APPENDIX B

WAIVER OF RESPONSIBILITY

Monterey, California Date _____

In consideration of the benefits conferred on _____

_____ by LCDR GILBERT M. MARLOWE, USN, by supplying the undersigned with free alcoholic beverages for the purpose of testing the effect of the alcohol on the undersigned's information processing and providing the undersigned with transportation to the undersigned's quarters following said testing, the undersigned hereby and herewith agrees to waive and forever release all claims, demands, damages, actions, causes of action, or suits at law or in equity against LCDR GILBERT M. MARLOWE, USN, which may now or in the future arise as a result of any injuries, losses, damages, cost, and/or expenses suffered by the undersigned during or incident to the aforementioned activities. Furthermore, the undersigned agrees to hold LCDR GILBERT M. MARLOWE, USN, harmless from any and all claims, demands, damages, actions, causes of action, or suits at law or in equity which may arise against him as a result of participation by the undersigned in the above-mentioned activities or incident to the above-mentioned activities.

_____

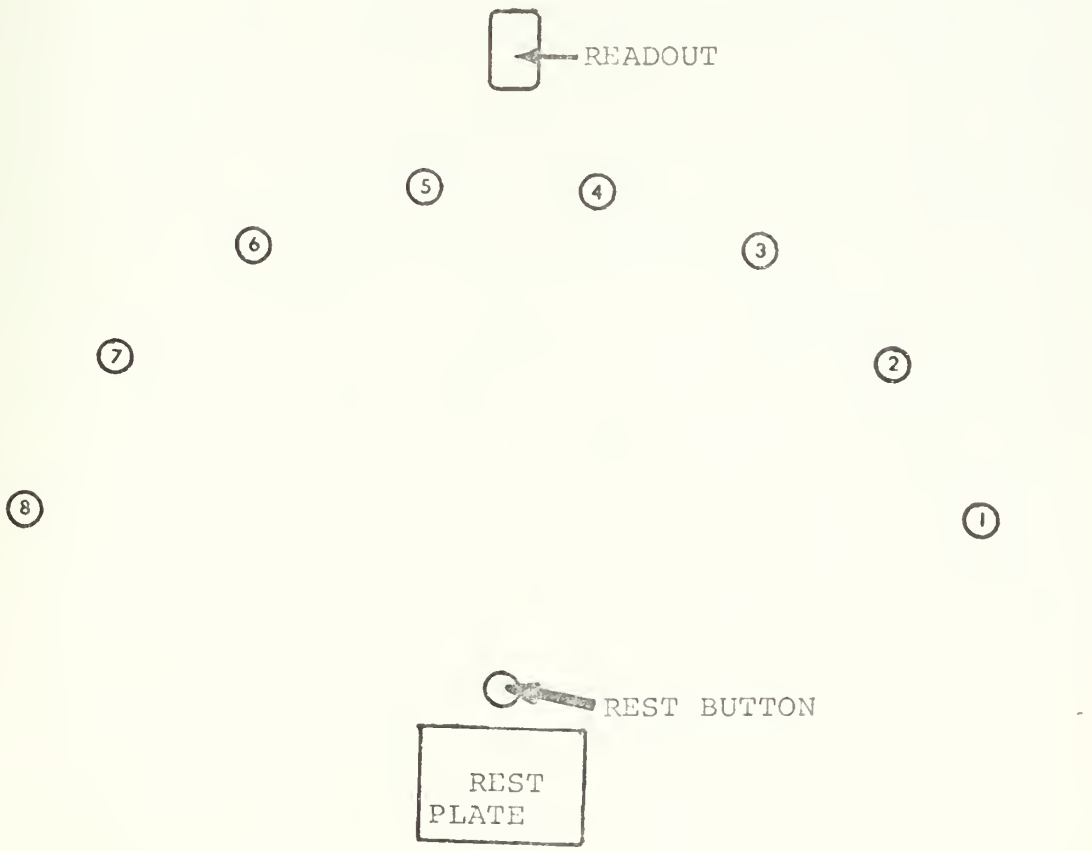
APPENDIX C

INSTRUCTIONS TO SUBJECTS

The purpose of this test is to measure reaction time, movement time and information processing rate and how they are affected by alcohol ingestion. For the purposes of conformity between subjects being tested, the following instructions are listed:

1) Place forefinger of left or right hand on rest button. Place other hand on rest plate. Rest button is single button closest to edge of table.
   Note: This button is energized continuously when depressed.

2) When the zero shown on stimulus light changes to a random number 1 through 8 remove finger from rest button and punch appropriate number button. Note: Buttons are numbered counter-clockwise 1 through 8 as shown below.



3) When the correct response is made, the number on light will change back to zero. At correct response immediately return your forefinger to the rest button. The next number will not be generated until after the rest button is re-energized.

Time is the scale on which all movements are measured. It is imperative that all movements be made as quickly as possible.

Each test in the series will consist of 50 trials.

Appendix D

DATA EXTRACTION PROGRAM

```
3 REM -DATA COLLECTION PROGRAM ALCOHOL TEST
50 DIM A(4,5),B(53),C(53),D(53),E(53)
60 I=1000\K=50000
80 FOR J=1 TO 5
90 FOR I=1 TO 53
100 SET RATE 3,1
110 IF ADC(1)<.1G) TO 110
120 A(1)=TI4(3)
200 IF ADC(2)>.3G) TO 200
210 A(2)=TI4(3)
300 IF ADC(3)<.1G) TO 300
310 A(3)=TI4(3)
400 IF ADC(2)<.1G) TO 400
410 A(4)=TI4(3)
420 B(I)=A(2)-A(1)-350
430 C(I)=A(3)-A(2)
440 D(I)=A(4)-A(3)+300
450 E(I)=C(I)-D(I)
460 NEXT I
500 PRINT "THAT'S 50!"
510 FOR I=1 TO 53
520 A(1,J)=A(1,J)+B(I)
530 A(2,J)=A(2,J)+C(I)
540 A(3,J)=A(3,J)+D(I)
550 A(4,J)=A(4,J)+E(I)
560 NEXT I
590 PRINT "TURN ON THE TAPE PUNCH, THEN TYPE A 1.
595 INPUT Q1
600 PTP
610 FOR I=1 TO 53
620 PRINT B(I),C(I),D(I),E(I)
630 NEXT I
640 TTY OUT
645 PRINT "ALL TIMES ARE IN SECONDS."
650 PRINT "N","REACT","RESP","ADVE","INFO"
660 FOR I=1 TO 50
670 PRINT I,B(I)/T,C(I)/T,D(I)/T,E(I)/T
680 NEXT I
700 PRINT "AVERAGE STATISTICS ON RUN"J
710 PRINT "REACT"A(1,J)/K"RESP"A(2,J)/K
711 PRINT "ADVE"A(3,J)/K"INFO"A(4,J)/K
720 NEXT J
730 PRINT "REACTION TIMES"
740 PRINT A(1,1)/T,A(1,2)/T,A(1,3)/T,A(1,4)/T,A(1,5)/T
750 PRINT "RESPONSE TIMES"
760 PRINT A(2,1)/T,A(2,2)/T,A(2,3)/T,A(2,4)/T,A(2,5)/T
770 PRINT "ADVERENT TIMES"
780 PRINT A(3,1)/T,A(3,2)/T,A(3,3)/T,A(3,4)/T,A(3,5)/T
790 PRINT "INFORMATION PROCESSING TIMES"
795 PRINT A(4,1)/T,A(4,2)/T,A(4,3)/T,A(4,4)/T,A(4,5)/T
800 END
```

APPENDIX E
RAW DATA
Subject History

Subject Number	Predom. Hand	Test Period Sequence	Dose	Final Mg %	Age	Ht	Wt	Drinking History Years	Drinking History Type	Anxiety Scores	
		1	12							42	44
1.	Left	2	0	162.8	33	70	199	15	3	43	38
Difference										7	
		1	12							49	79
2.	Left	2	0	203.7	30	70	159	15	12	46	44
Difference										32	
		1	12							51	82
3.	Left	2	0	174.2	32	$75\frac{3}{4}$	186	14	3	54	56
Difference										29	
		2	9							29	33
4.	Right	1	0	133.5	30	$70\frac{3}{4}$	162	13	12	35	32
Difference										7	
		2	9							28	29
5.	Right	1	0	138.8	32	74	175	10	8	25	22
Difference										4	
		1	9							21	23
6.	Right	2	0	130.6	38	73	186	22	8	30	20
Difference										12	
		1	6							24	24
7.	Left	2	0	76.4	30	76	212	14	8	21	14
Difference										7	
		1	6							30	30
8.	Right	2	0	104.5	32	70	155	15	12	24	22
Difference										2	
		2	6							16	17
9.	Right	1	0	96.4	31	70	168	8	1	21	17
Difference										5	

APPENDIX E

RAW DATA

Subject Number	Information Processing Time				
	1	2	3	4	5
	9.21	13.488	18.62	21.033	24.664
1	8.59	4.237	11.67	10.189	11.38
Difference	0	8.631	6.33	10.224	13.222
2	6.942	9.784	18.599	18.68	14.078
	5.604	6.671	6.004	7.028	4.956
Difference	0	1.775	11.257	10.314	7.784
3	9.25	10.904	19.268	22.706	21.089
	8.671	9.877	9.835	10.13	12.636
Difference	0	0.528	8.854	11.997	7.874
4	4.83	5.972	6.873	8.915	10.437
	7.131	6.706	6.590	7.040	7.002
Difference	0	1.567	2.584	4.176	5.736
5	6.89	10.945	10.123	10.921	11.983
	5.383	5.967	5.428	5.949	5.243
Difference	0	3.451	3.188	3.465	5.233
6	8.302	11.433	12.526	12.705	12.814
	5.468	5.188	6.174	6.819	5.202
Difference	0	3.411	3.518	3.052	4.778
7	4.28	8.55	7.608	6.816	7.273
	3.85	6.7	5.918	5.806	5.216
Difference	0	1.42	1.26	0.58	1.63
8	12.14	15.733	19.769	20.291	20.565
	10.636	11.951	11.995	11.574	11.009
Difference	0	2.278	6.27	7.216	8.052
9	3.147	4.832	5.567	6.465	6.637
	4.82	4.149	3.69	3.939	0.035
Difference	0	2.361	3.55	4.199	8.275

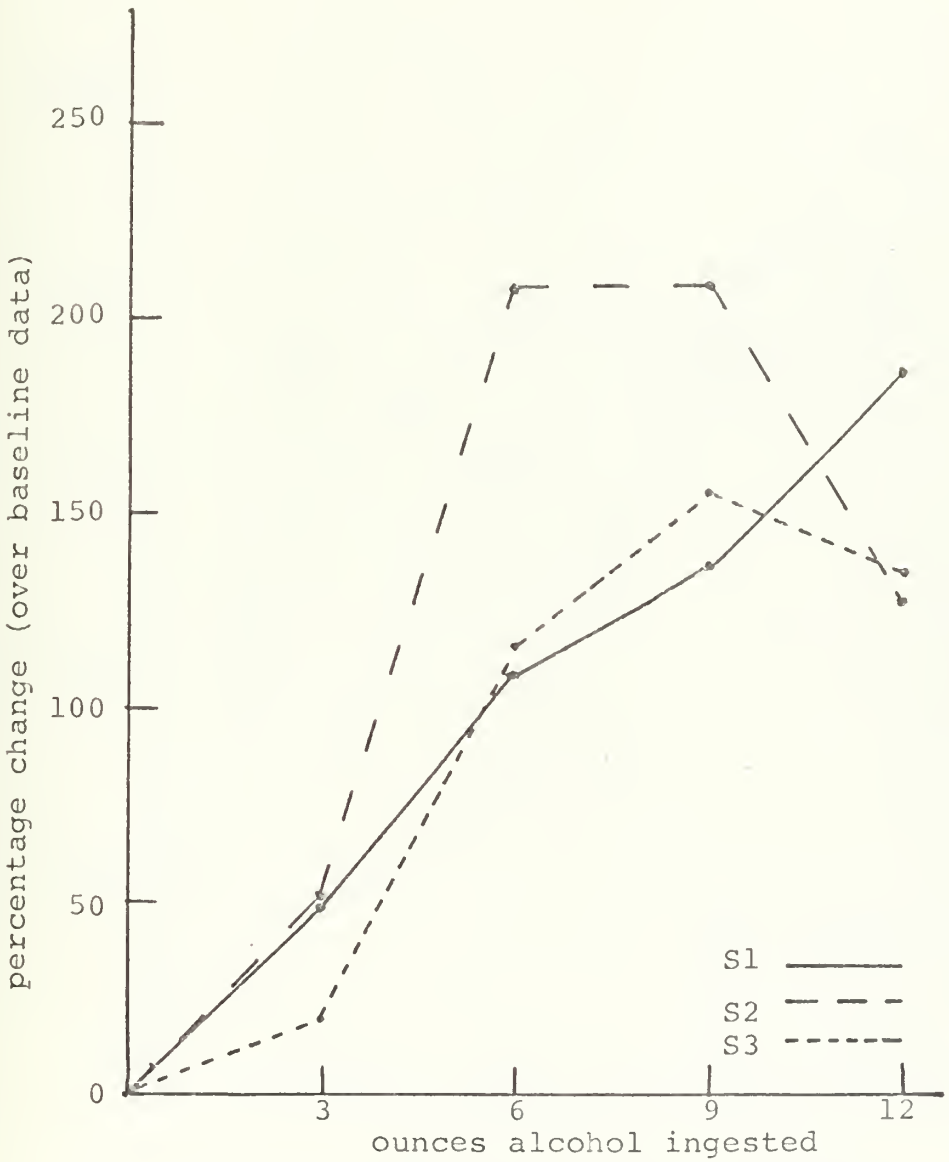
APPENDIX E
RAW DATA

Subject Number	Reaction Time				
	1	2	3	4	5
	25.2	30.0	37.81	41.384	45.43
1	23.8	23.93	22.93	21.405	41.01
Difference	0	4.67	13.48	18.579	23.02
	19.78	22.932	37.89	41.77	38.55
2	18.477	20.472	20.365	20.358	19.065
Difference	0	1.157	16.222	20.109	18.182
	19.473	21.328	28.587	30.755	29.362
3	15.456	16.078	16.58	15.288	16.155
Difference	0	1.233	7.99	11.45	9.19
	23.5	26.251	30.233	30.724	32.197
4	21.3	18.508	19.222	19.872	20.097
Difference	0	6.543	8.811	8.652	9.9
	10.385	11.89	11.763	16.862	12.404
5	12.293	13.199	12.18	10.307	12.871
Difference	0	0.599	1.491	5.463	6.441
	18.319	20.674	21.188	19.467	22.13
6	24.892	19.322	18.578	16.696	16.983
Difference	0	8.125	9.183	2.344	11.72
	20.361	26.631	26.268	24.943	22.96
7	19.427	15.447	15.623	16.239	15.782
Difference	0	10.25	9.711	7.77	6.244
	18.917	18.444	21.07	21.772	20.104
8	24.845	21.038	21.615	21.89	20.888
Difference	0	3.334	3.383	5.81	5.144
9	18.59	19.371	21.614	21.344	19.731
	20.21	18.4	17.8	17.2	16.9
Difference	0	2.591	5.434	5.764	4.451

APPENDIX E
RAW DATA

Subject Number	Movement Time				
	1	2	3	4	5
	33.23	32.017	28.89	27.059	29.505
1	32.311	35.203	28.126	29.185	27.584
Difference	0	-3.905	0.045	-2.845	1.202
	40.616	46.146	41.147	37.865	44.406
2	39.188	37.574	37.723	37.407	38.528
Difference	0	7.144	1.996	-0.97	4.45
	33.77	30.57	30.681	34.994	41.349
3	33.069	31.843	31.02	30.416	29.072
Difference	0	-1.974	-1.04	3.877	11.576
	31.8	32.723	31.203	30.22	29.647
4	33.196	30.685	30.005	31.26	30.828
Difference	0	3.434	2.594	0.356	0.215
	35.384	35.162	36.273	36.18	35.687
5	37.82	38.371	37.618	37.097	36.534
Difference	0	-0.773	1.091	1.519	1.589
	33.222	31.558	32.075	35.86	35.812
6	39.353	37.883	37.115	35.698	34.821
Difference	0	-0.194	1.091	6.293	7.122
	41.82	42.267	41.582	42.111	44.85
7	41.205	39.283	39.585	38.44	38.482
Difference	0	2.369	1.382	3.056	5.753
	29.861	30.444	31.129	30.874	30.769
8	29.629	30.202	30.224	30.305	30.125
Difference	0	0.01	0.673	0.337	0.412
	36.77	36.054	35.432	36.396	36.129
9	35.88	35.049	35.893	35.444	36.093
Difference	0	0.115	-1.351	0.062	-0.854

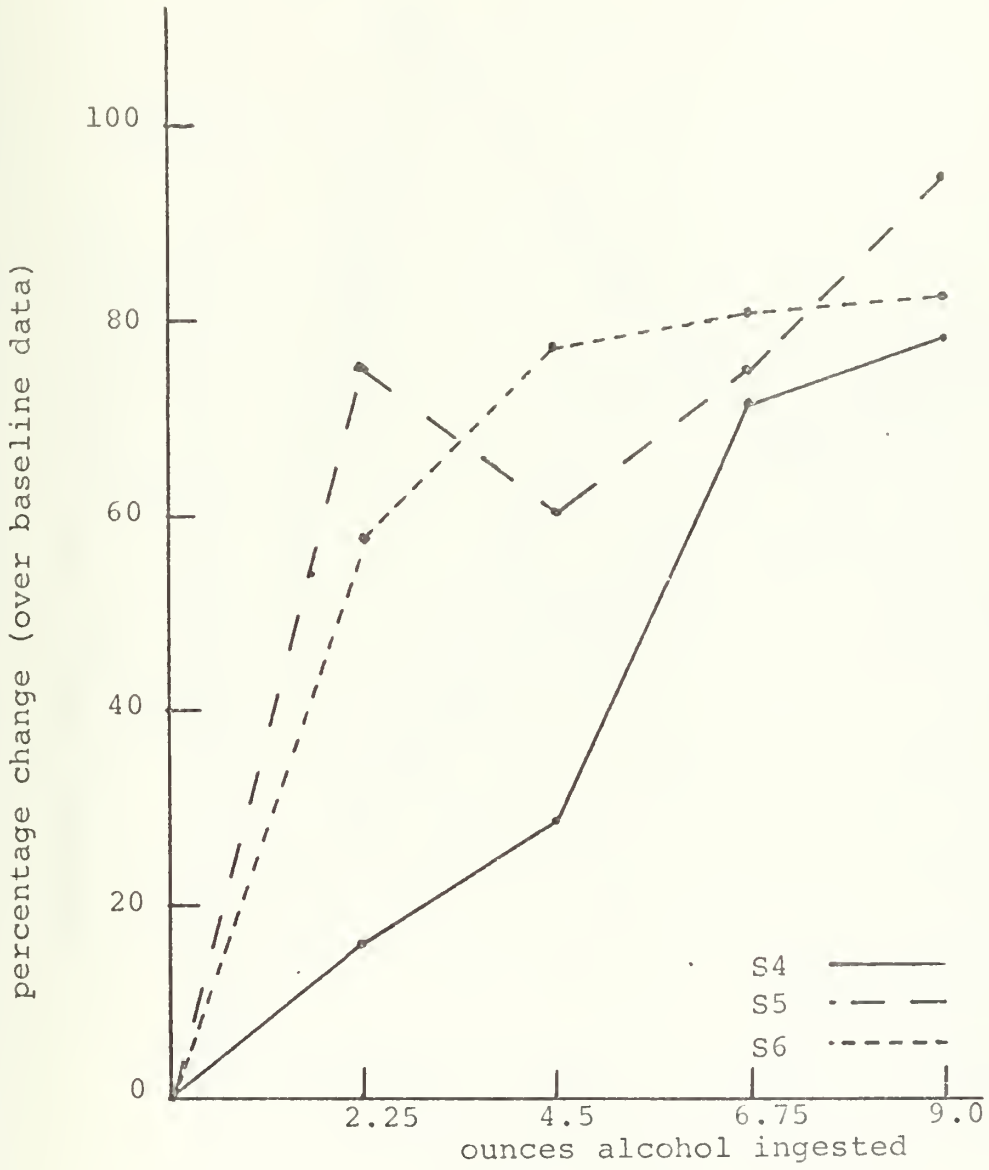
Appendix F



VISUAL INFORMATION PROCESSING TIME

12 OUNCES

Appendix F



VISUAL INFORMATION PROCESSING TIME

9 OUNCES

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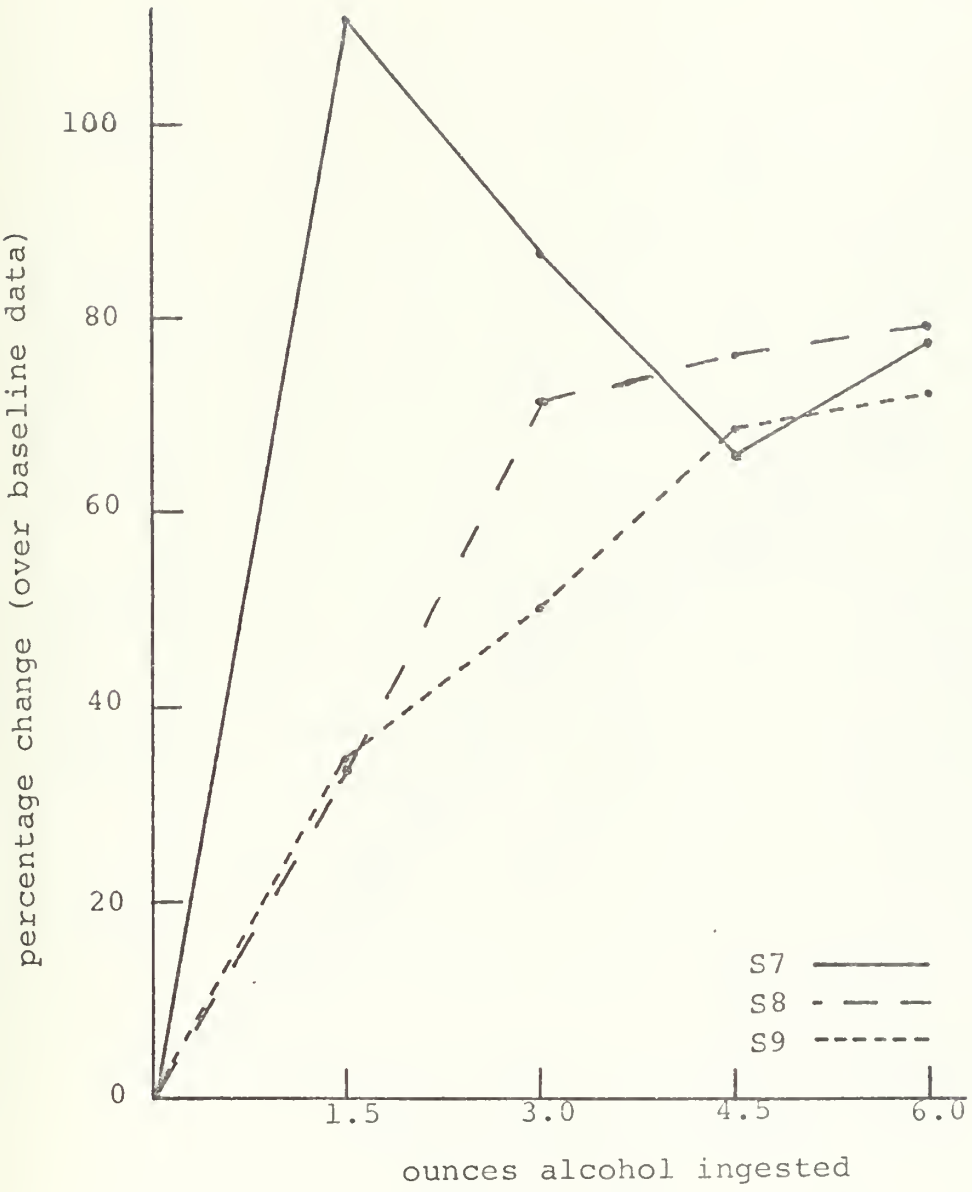

VISUAL INFORMATION PROCESSING TIME

6 OUNCES

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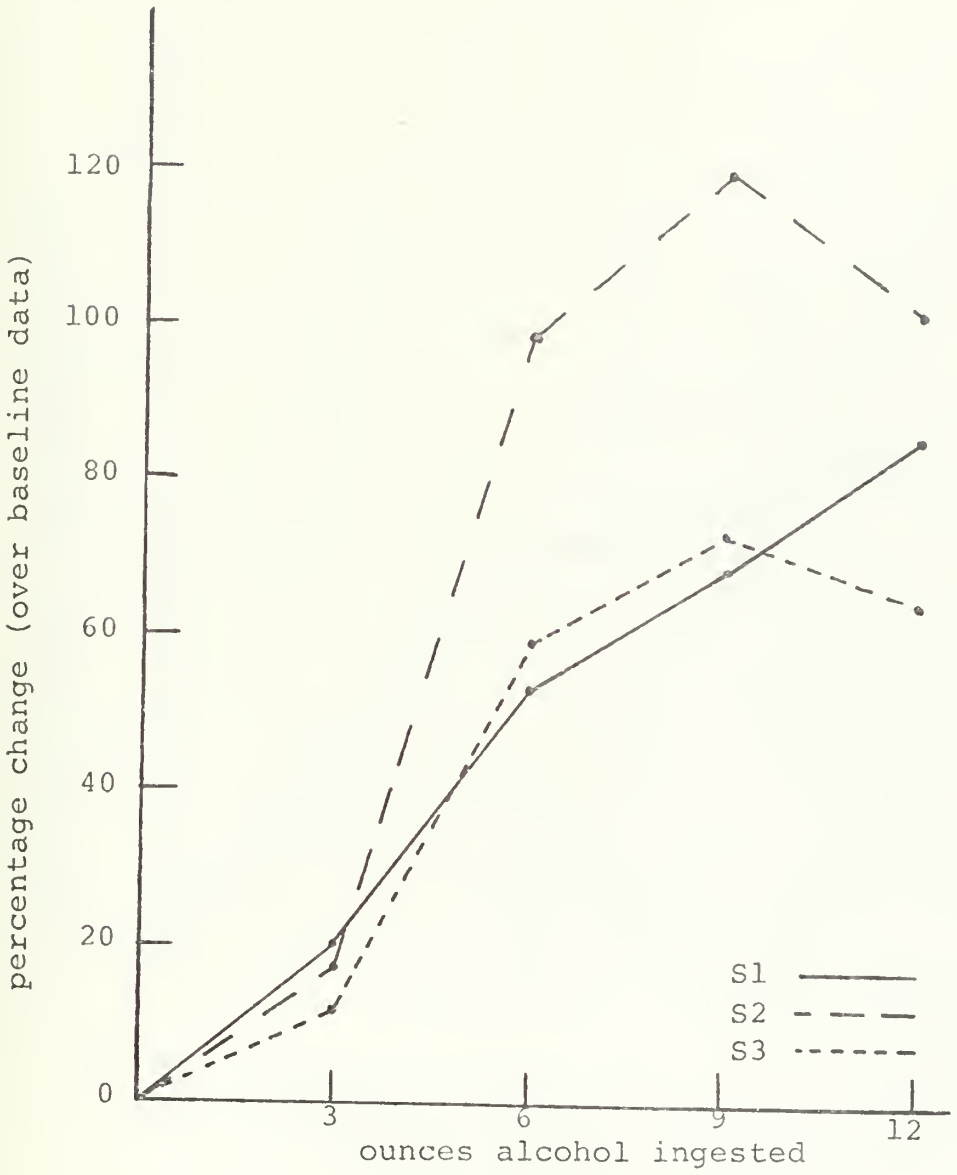

REACTION TIME

12 OUNCES

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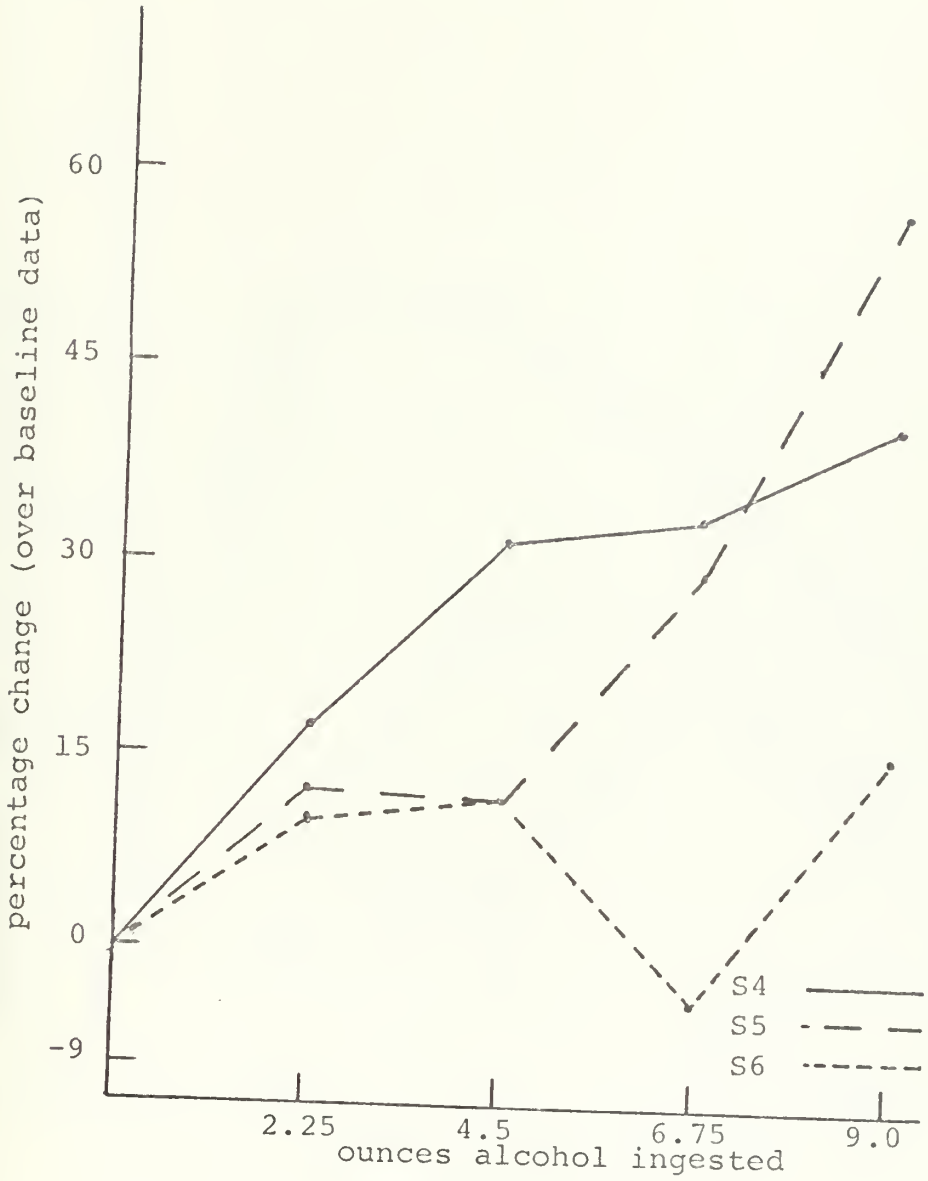

REACTION TIME

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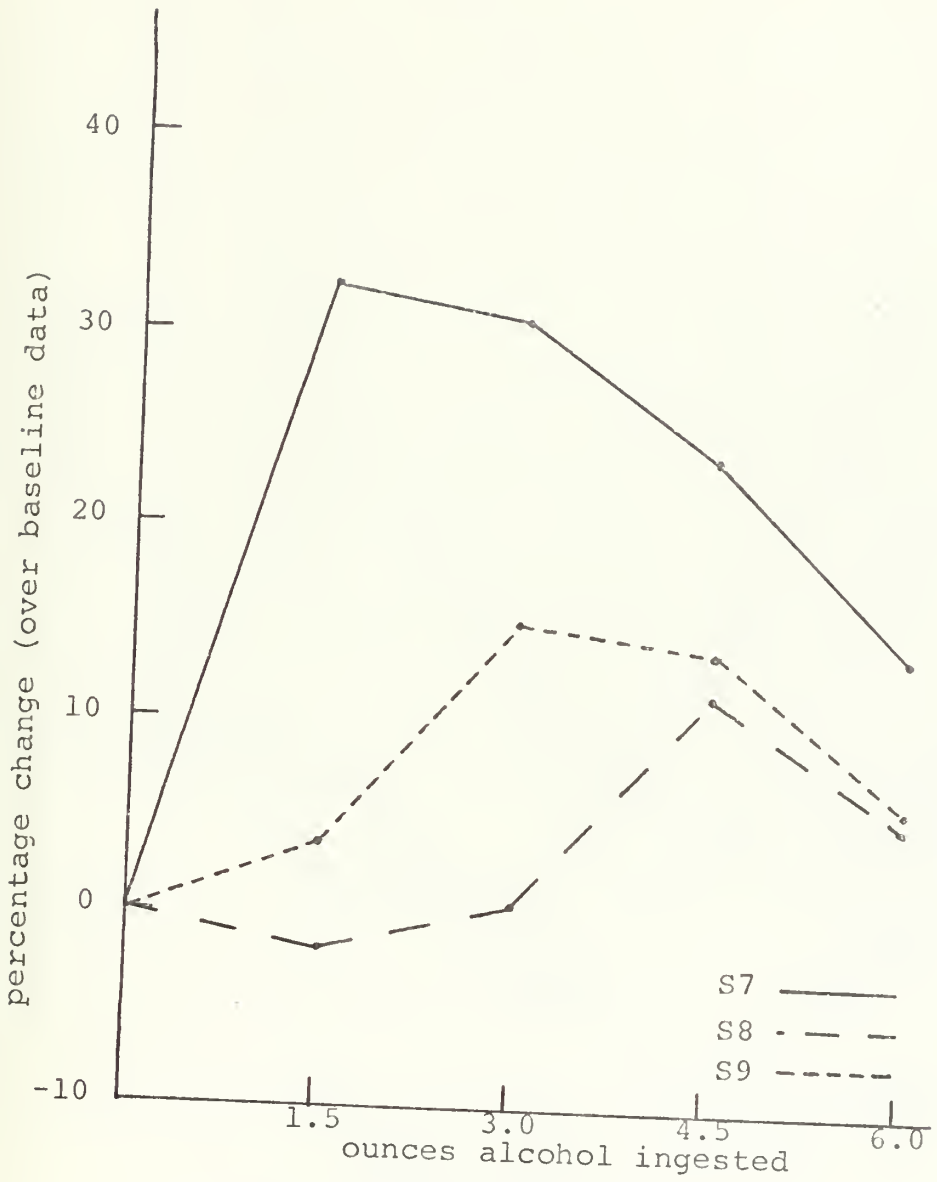

REACTION TIME

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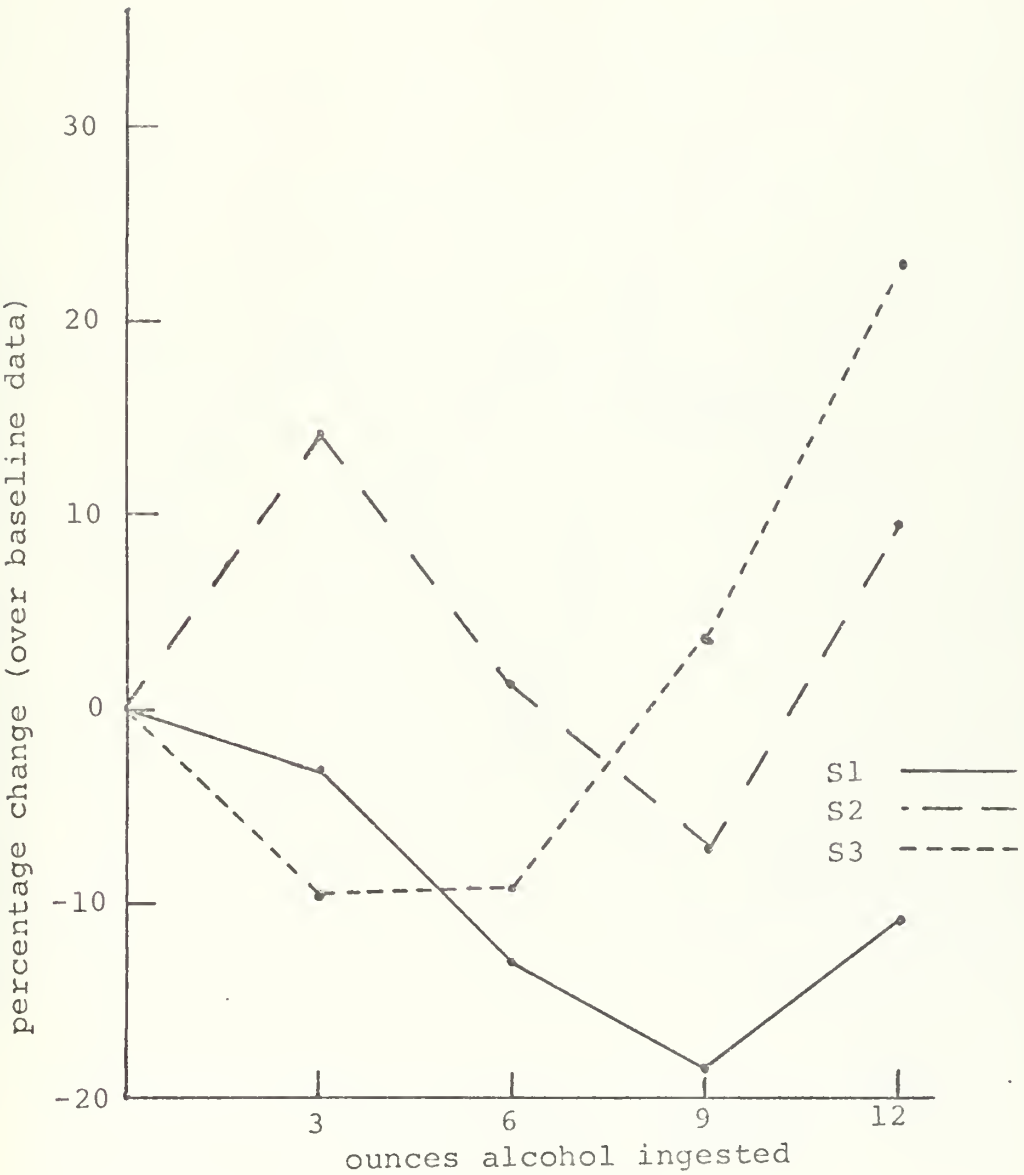

MOVEMENT TIME

12 OUNCES

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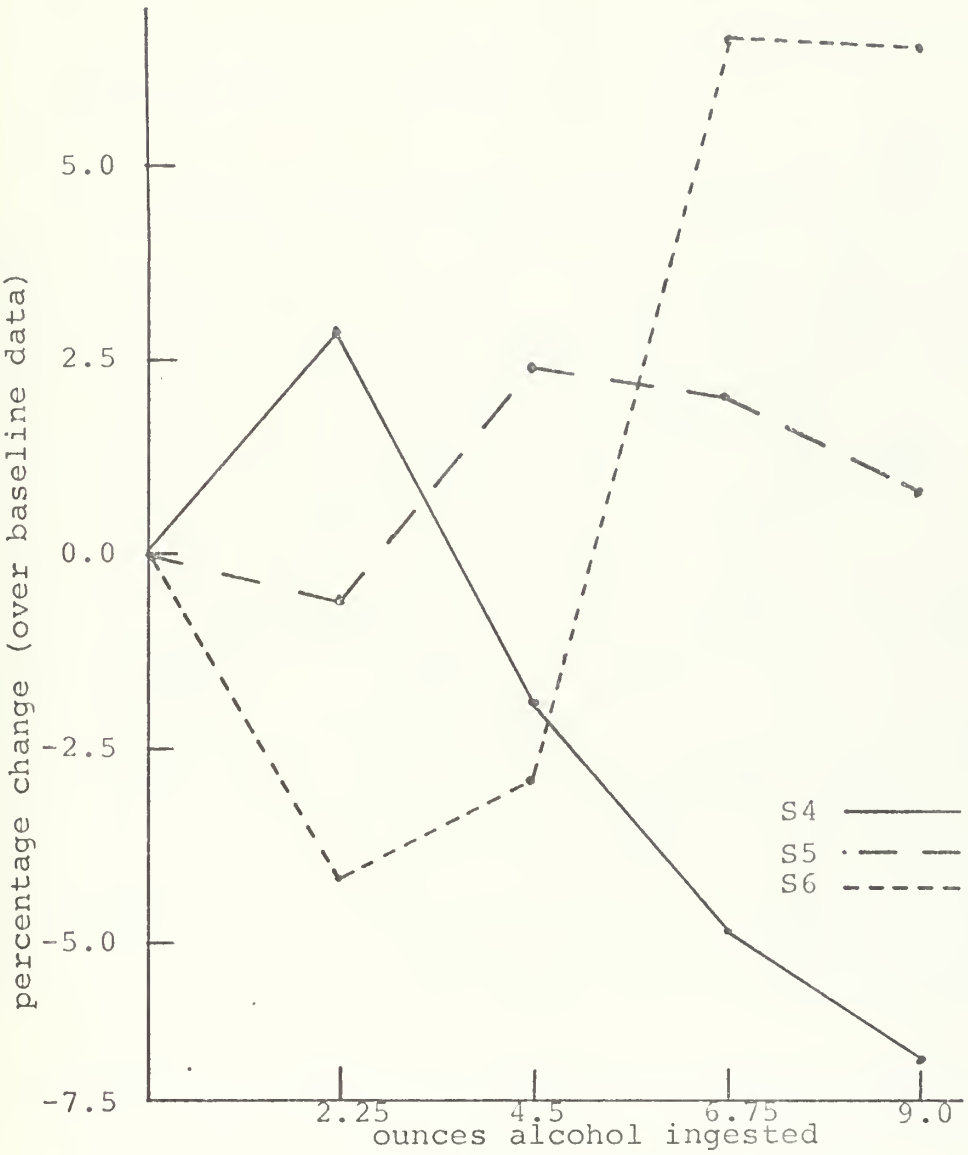

MOVEMENT TIME

9 OUNCES

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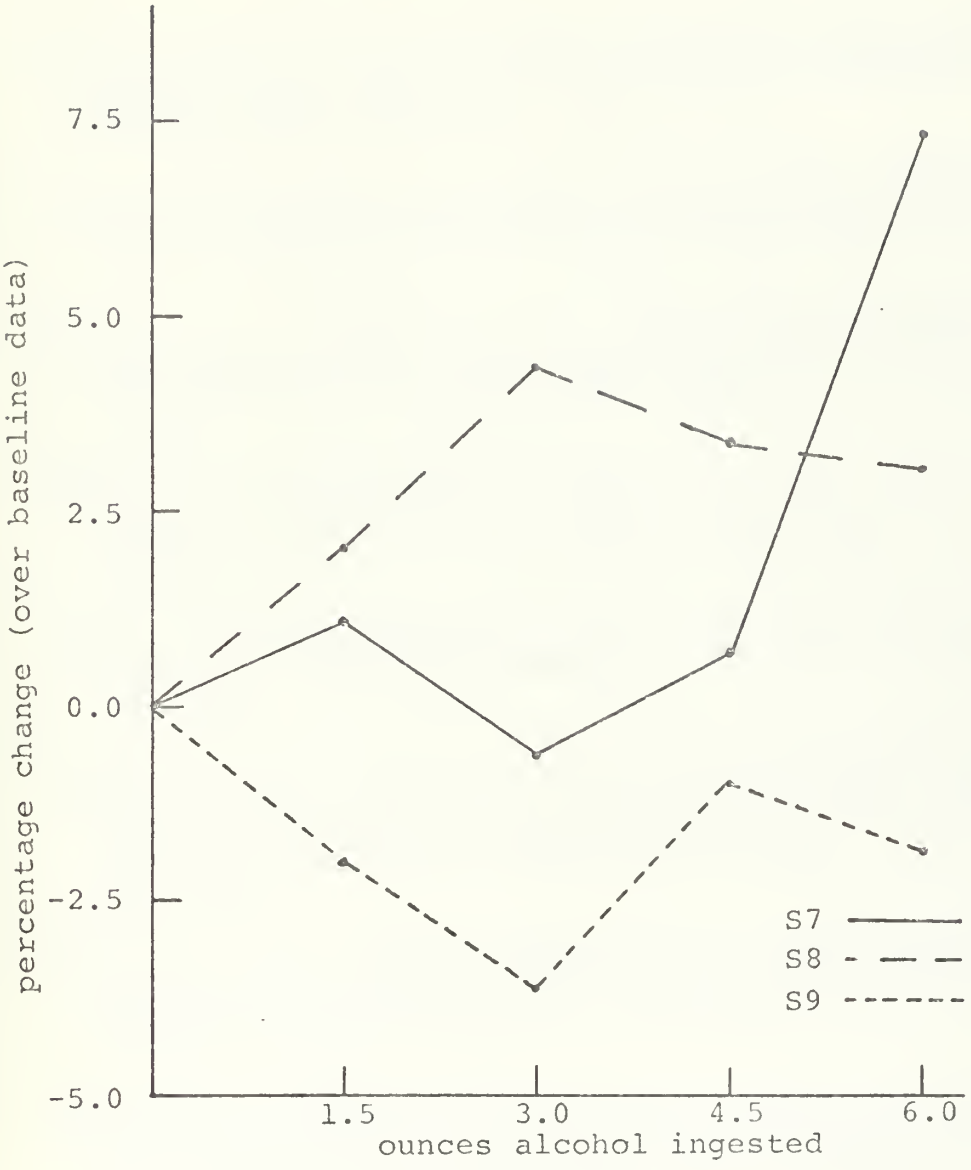

MOVEMENT TIME

6 OUNCES

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This experiment investigated the effects of alcohol ingestion on three measures of human performance: (a) information processing time, (b) reaction time and (c) movement time. The relationship between the alcohol effects and the drinking history of the subjects was also examined in order to determine the existence of any alcohol adaptation. In addition, the influence of alcohol on manifest anxiety was investigated. The analyses of variance and correlation analysis which were performed showed that

dosage had a significant effect on information processing time and reaction time but had no significant effect on movement time. The rate of ingestion, except at the highest rate of 3 oz/35 min, did not significantly contribute to the effects of dosage. There was no significant correlation between alcohol effects and drinking history or manifest anxiety changes. The results of this study indicate that, even at small dosages, alcohol has a great effect on cognitive ability. It was also shown that alcohol effects psychomotor performance to a lesser degree and has little effect on neuromuscular performance.